Development of a Low-Cost, Durable Membrane and Membrane Electrode Assembly for Stationary and Mobile Fuel Cell Applications (New FY 2004 Project)

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Objectives

- Develop low-cost, high-durability membranes and membrane electrode assemblies (MEAs) for polymer electrolyte membrane (PEM) fuel cells.
- Improve the Kynar® polyvinylidenefluoride (PVDF) based membrane, particularly regarding conductivity and water management. The result of this work will be an optimized composition of Atofina's polymer alloy yielding a high-conductivity/low-cost membrane at the laboratory scale.
- Prepare suitable electrodes for the Kynar® PVDF membrane.
- Develop manufacturing processes for polyelectrolyte ionomer, membranes, and high-performance MEAs.
- Run long-term endurance tests in fuel cells, evaluate possible degradation and degradation mechanisms and, in parallel, develop accelerated tests to provide faster feedback to the synthetic effort related to the membrane and the polyelectrolyte ionomer.

Technical Barriers

This project addresses the following technical barrier from the Fuel Cells section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year R,D&D Plan:

- O. Stack Material and Manufacturing Cost

Approach

The objective of this project is to develop low-cost, high-durability membranes and membrane electrode assemblies (MEAs) for polymer electrolyte membrane (PEM) fuel cells. The team members, lead by Atofina, are Johnson Matthey Fuel Cells, UTC Fuel Cells, the Georgia Institute of Technology and the University of Hawaii.

The technical approach is based on technology developed by Atofina exploiting the unique properties of its Kynar® polyvinylidenefluoride (PVDF). Kynar® offers a unique combination of exceptional chemical and electrochemical stability, excellent mechanical properties, low flame and smoke properties, and recyclability at a low cost. Atofina turned to its own fluoropolymers technology to seek cost-effective solutions, which also could offer several other significant benefits in terms of improved mechanical properties and high-temperature performance. These membranes and MEAs have the potential to operate at higher temperatures than conventional fluoroionomers (of the Nafion® type) and offer high durability.

The mechanical characteristics of membranes prepared from Kynar® PVDF are excellent. The films are sturdy; they show very good tear resistance and negligible creep at all temperatures tested (as high as 120°C). Johnson Matthey Fuel Cells reported permeability to hydrogen on the order of 1/3 of that of Nafion, a very desirable property. The combination of excellent mechanical properties and low gas permeability offers the exciting prospect to make high-performance, thin membranes. In this respect, it is noteworthy that it is the resistance of the membrane/MEA which dictates proton conductivity – not the intrinsic conductivity (i.e., thinner membranes have a lower resistance than thicker membranes).

The project's technical work is divided into three major tasks. Task 1 is membrane development led by Atofina in collaboration with Georgia Tech, particularly on high-throughput membrane composition screening and characterization. The deliverables of Task 1 are a high-conductivity, low-cost membrane (lab scale). Task 2, MEA development, is led by Johnson Matthey Fuel Cells, with substantial input from Atofina for the polyelectrolyte ionomer. The deliverable of Task 2 is a high-performance, low-cost MEA produced on a pilot line featuring high durability. Task 3, cell and stack development and verification, is led by UTC Fuel Cells with the help of the University of Hawaii. The product of Task 3 will be a multiple-cell stack meeting DOE's goals. The three tasks will be conducted in sequence with substantial overlap for feedback loops. The total duration of the project is anticipated to be 36 months.

Atofina is the fourth largest chemical company in the world. It has a major focus on thermoplastics polymers, and it is the largest producer of PVDF. The project will be conducted in its state-of-the-art Research Center located in King of Prussia, Pennsylvania. Johnson Matthey Fuel Cell (JMFC) is a business unit of Johnson Matthey PLC, a specialty chemicals company and a leader in platinum and platinum catalysts. JMFC is a leading developer of fuel cell components, particularly catalysts and MEAs. The work will be carried out primarily in West Chester, Pennsylvania. UTC Fuel Cells (UTCFC) is a unit of the United Technologies Corporation and is a leader in the development, manufacturing, and operations of fuel cell power plants. Their part of the project will be conducted partly in South Windsor, Connecticut, and partly at the University of Hawaii. The University of Hawaii, in collaboration with the Hawaiian Electric Company, UTCFC and the Office of Naval Research, has established a first class facility for testing and evaluating full-size single-cell and multi-cell fuel cell stacks. Georgia Tech has very special expertise in the field of high-throughput and combinational techniques. Atofina will utilize these techniques to screen and optimize large numbers of compositions in an efficient manner.